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Bio-plausible simulation of three monoamine systems to replicate emotional phenomena in a machine

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Abstract

© 2018 The Authors. Published by Elsevier B.V. In this paper we present the validation of the three-dimensional model of emotions by Hugo Lövheim the "cube of emotion" via neurosimulation in the NEST. We also present the extension of original "cube of emotion" with the bridge to computational processes parameters. The neurosimulation is done via re-implementation of dopamine (DA), serotonin (5-HT) and noradrenaline (NA) subsystems of a rat brain to replicate 8 basic psycho-emotional states according to the "cube of emotion". Results of neu-rosimulations indicate the incremental influence of DA and NA over computational resources of a psycho-emotional state while 5-HT decreases the computational resources used to calculate a psycho-emotional state. This way we indicate the feasibility of the bio-plausible re-implementation of psycho-emotional states in a computational system. This approach could be useful extension of decision making and load balancing components of modern artificial agents as well as intelligent robotic systems.

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Keywords

affective computation, affective computing, bio-inspired cognitive architecture, spiking neural networks

References

[1] Berridge K., and Robinson T. What is the role of dopamine in reward: hedonic impact reward learning, or incentive salience? Brain research reviews 28 1998 309 369

[2] Bosch-Bouju C., Hyland B., and Parr-Brownlie L. Motor thalamus integration of cortical, cerebellar and basal ganglia information: implications for normal and parkinsonian conditions Frontiers in Computational Neuroscience 7 2013 163

[3] Boussida S., Traoré A., and Durif F. Mapping of the brain hemodynamic responses to sensorimotor stimulation in a rodent model: A bold fmri study PLoS ONE 12 2017 15

[4] Bridges M., Distefano S., Mazzara M., Minlebaev M., Talanov M., and Vallverdú J. Towards anthropo-inspired computational systems: The p model Smart Innovation, Systems and Technologies 2015 Springer International Publishing 311 321 volume 38

[5] Counts S.E., and Mufson E.J. Chapter 12 - locus coeruleus The Human Nervous System third ed. 2012 Academic Press 425 438

[6] Durieux P., Schiffmann S., and de Kerchove d'Exaerde A. Targeting neuronal populations of the striatum Frontiers in Neuroanatomy 5 2011 40

[7] Feldmeyer D. Excitatory neuronal connectivity in the barrel cortex Frontiers in Neuroanatomy 6 2012 24

[8] Hornung J.P. The human raphe nuclei and the serotonergic system Journal of Chemical Neuroanatomy 26 2003 331 343

[9] Jaeger D., and Kita H. Functional connectivity and integrative properties of globus pallidus neurons Neuroscience 198 2011 44 53 Function and Dysfunction of the Basal Ganglia.

[10] Kugurakova, V., Talanov, M., Manakhov, N., Ivanov, D., 2015. Anthropomorphic artificial social agent with simulated emotions and its implementation, in: Procedia Computer Science, pp. 112-118.

[11] Kunkel S., and Schenck W. The nest dry-run mode: Efficient dynamic analysis of neuronal network simulation code Frontiers in neuroin-formatics 11 2017 40

[12] Leukhin A., Talanov M., Sozutov I., Vallverdú J., and Toschev A. Simulation of a fear-like state on a model of dopamine system of rat brain Biologically Inspired Cognitive Architectures (BICA) for Young Scientists 2016 Springer 121 126

[13] Lövheim H. A new three-dimensional model for emotions and monoamine neurotransmitters Medical hypotheses 78 2012 341 348

[14] Lübke J., and Feldmeyer D. Excitatory signal flow and connectivity in a cortical column: focus on barrel cortex Brain Structure and Function 212 2007 3 17

[15] Mai J.K., and Forutan F. Chapter 19 - thalamus The Human Nervous System third ed. 2012 Academic Press 618 677

[16] Oatley K., Keltner D., and Jenkins J.M. Understanding emotions 2006 Blackwell publishing

[17] Schultz W. Predictive reward signal of dopamine neurons Journal of neurophysiology 80 1998 1 27

[18] Talanov M., Gafarov F., Vallverdú J., Ostapenko S., Gazizov M., Toschev A., Leukhin A., and Distefano S. Simulation of serotonin mechanisms in neucogar cognitive architecture Procedia Computer Science 123 2018 473 478

[19] Talanov M., Toschev A., and Leukhin A. Modelingthe fear-like state in realistic neural network BioNanoScience 7 2017 446 448

[20] Talanov, M., Vallverdú, J., Distefano, S., et al., 2015. Neuromodulating cognitive architecture: Towards biomimetic emotional ai, in: Advanced Information Networking and Applications (AINA), pp. 587-592.

[21] Talanov, M., Zagulova, M., Distefano, S., Pinus, B., Leukhin, A., Vallverdu, J., 2017b. The implementation of noradrenaline in the neucogar cognitive architecture, in: Proceedings of the Ninth International Conference on Advanced Cognitive Technologies and Applications, IARIA XPS Press. pp. 10-15.

[22] Talanov, M., Zykov, E., Gerasimov, Y., Toschev, A., Erokhin, V., 2017c. Dopamine modulation via memristive schematic. CoRR abs/1709.06325.

[23] Tchitchigin A., Talanov M., Safina L., and Mazzara M. Neuromorphic robot dream BioNanoScience 7 2017 199 200

[24] Vallverdú J. Ekman's paradox and a naturalistic strategy to escape from it International Journal of Synthetic Emotions (IJSE) 4 2013 1 7

[25] Vallverdú, J., Talanov, M., Distefano, S., et al., 2015. A cognitive architecture for the implementation of emotions in computing systems. Biologically Inspired Cognitive Architectures.

[26] Voigt B.C., and et al. Behavioral detectability of single-cell stimulation in the ventral posterior medial nucleus of the thalamus Journal of Neuroscience 28 2008 12362 12367